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Keywords Bayesian model averaging, cellulosic biofuels, corn, greenhouse gas, poplar, restored prairie, switchgrass, nitrous oxide, methane, carbon dioxide

Scientific Names Panicum virgatum, Miscanthus giganteus, Populus nigra × P. maximowiczii, Zea mays

Spatial Coverage Arlington Agricultural Research Station, Kellogg Biological Station, AARS, KBS, Wisconsin, Michigan, United States, GLBRC Biofuel Cropping System Experiment

Abstract

Greenhouse gas (GHG) emissions from soils are a key sustainability metric of cropping systems. During crop establishment, disruptive land-use change is known to be a critical, but under reported period, for determining GHG emissions. We measured soil N2O emissions and potential environmental drivers of these fluxes from a three-year establishment-phase bioenergy cropping systems experiment replicated in southcentral Wisconsin (ARL) and southwestern Michigan (KBS). Cropping systems treatments were annual monocultures (continuous corn, corn–soybean–canola rotation), perennial monocultures (switchgrass, miscanthus, and poplar), and perennial polycultures (native grass mixture, early successional community, and restored prairie) all grown using best management practices specific to the system. Cumulative three-year N2O emissions from annuals were 142% higher than from perennials, with fertilized perennials 190% higher than unfertilized perennials. Emissions ranged from 3.1 to 19.1 kg N2O-N ha−1 yr−1 for the annuals with continuous corn > corn–soybean–canola rotation and 1.1 to 6.3 kg N2O-N ha−1 yr−1 for perennials. Nitrous oxide peak fluxes typically were associated with precipitation events that closely followed fertilization. Bayesian modeling of N2O fluxes based on measured environmental factors explained 33% of variability across all systems. Models trained on single systems performed well in most monocultures (e.g., R2 = 0.52 for poplar) but notably worse in polycultures (e.g., R2 = 0.17 for early successional, R2 = 0.06 for restored prairie), indicating that simulation models that include N2O emissions should be parameterized specific to particular plant communities. Our results indicate that perennial bioenergy crops in their establishment phase emit less N2O than annual crops, especially when not fertilized. These findings should be considered further alongside yield and other metrics contributing to important ecosystem services.

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